PERFORMANCE OF POROUS ASPHALT INCORPORATING STEEL FIBER

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Asfalt berliang (AB) merupakan salah satu jenis turapan lentur yang dikenali sebagai turapan yang mempunyai keupayaan kebolehtelapan yang direka bentuk untuk mengawal air hujan dan mengurangkan air larian permukaan. Walau bagaimanapun, struktur adalah tertakluk kepada kerosakan dari keretakan, aluran, pelucutan dan penuaan pesat di bawah kesan beban kenderaan yang berulang di atas jalan raya, cuaca panas dan hujan lebat. Penggunaan gentian keluli manfaat dalam usaha meningkatkan kekuatan, tempoh hayat dan ketahanan turapan jalan kerana gentian keluli cenderung digunakan untuk kawalan retak dan mengukuhkan laluan itu dengan menentang tegangan keretakan. Oleh itu, tujuan kajian ini adalah untuk menilai prestasi campuran asfalt berliang dengan gentian keluli dan mengatasi masalah atau isu yang berkaitan dengan AB. Campuran mengandungi peratusan gentian keluli yang berbeza-beza dinilai untuk menyemak sampel yang memberikan prestasi yang terbaik mengikut keperluan dengan menggunakan ujian makmal LA lelasan, Resilient Modulus, kestabilan Marshall dan aliran dan Rayapan dinamik. Hasil kajian menunjukkan bahawa penambahan 0.6% gentian keluli memberi nilai yang paling rendah lelasan, manakala 0.5% kandungan serat menyumbang nilai tertinggi resilient modulus dan marshall kestabilan serta 0.3% untuk rayapan dinamik. Dengan kaedah peringkat atau kedudukan, kandungan gentian keluli yang optimum dapat dikenalpasti. Campuran PA diubah suai dengan gentian keluli menghasilkan peningkatan prestasi AB sebagai bahan permukaan jalan raya. Kesimpulannya, bahawa campuran asfalt yang mengandungi gentian keluli boleh meningkatkan kestabilan dan kekuatan campuran. Untuk kajian masa depan, ia adalah disyorkan untuk menganalisis kesan pelbagai panjang gentian keluli terhadap prestasi asfalt berliang dan prosedur reka bentuk yang sesuai bagi campuran asfalt berliang yang akan menyebabkan prestasi memuaskan AB semasa perkhidmatan.

ABSTRACT

Porous Asphalt (PA) is known as highly permeable asphalt surface that design to be permeable pavements for storm water control and reduce the storm water runoff. However, the structure is subjected to damage from cracking, rutting, stripping and rapid aging under the effects of repeated vehicle loading, hot climates and heavy rainfall. Application of steel fiber benefit in increasing the strength, life period and toughness of road pavement because steel fiber tend to be used to control of crack and strengthen the pavement by resisting tensile cracking. Thus, the aim of this study is to evaluate the performance of these porous asphalt mixtures with the steel fiber and overcome the issue that is related to PA. A mixture contains varying percentages of steel fiber were assessed to check which samples gives the best performance as per the requirement by using laboratory tests which is LA Abrasion, Resilient Modulus, Marshall Stability and Flow and Dynamic creep. The results show that the additions of 0.6% steel fiber give the lowest value of abrasion, while 0.5% fiber content contributes the highest value of Resilient Modulus and Marshall Stability respectively. While 0.3% fiber content is the best for dynamic creep. By ranking method, the optimum fiber content of 0.6% is obtained. PA mixtures modified with steel fiber produce the performance enhancement of PA as a road surfacing material. It is concluded that the asphalt mixtures containing steel fibers could be increases the stability and strength of the mix. For future studies, it is recommended to analyze the effect of various steel fiber length towards porous asphalt performance and an appropriate design procedure for porous asphalt mixture that will render the satisfactory performance of PA during service.

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LIST OF SYMBOLS

PA	Porous Asphalt
ENG	Engineering
AIV	Aggregate Impact Value
SMA	Stone Mastic Asphalt
ACV	Aggregate Crushing Value
OPFC	Open Graded Friction Course
OPA	Open Graded Asphalt
SMA	Stone Mastic Asphalt
DGA	Dense Graded Asphalt
SF	Steel Fiber
LA	Los Angeles

LIST OF ABBREVIATIONS

PA	Porous Asphalt
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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Porous Asphalt (PA) or known as Open Graded Friction Course (OGFC) is a highly permeable asphalt surface that act as a storm water management. The mixtures contain more coarse aggregates than fine aggregates. This PA is different from other types of asphalt because the water can penetrate into the pavements from surface into a recharge bed and permeate into the soils below the pavement. PA also has been verifying their quality since the mid-1970s (James, G, et al, 2016). This design can contribute profitable and worthwhile storm water management systems.

Fiber is an essential or fabricated material that has longer length than it is wide. It has been used in various areas including in the construction field. The fiber can be in many forms such as steel, polymer or natural materials. It also designed as substances that can upgrade the material properties, strengthening of pavement, resistance towards impact, flexural strength, decisiveness, fatigue protection and have good endurance. Moreover, Ahmed, S.A and Mahmood, O.T (2015) studied on the influence of mineral fibers properties. The study concluded that fiber can produced additional tensile strength and at times fibers are added to balance the bitumen during mixing and preparation of the samples.

Asphalt pavement has been used in roadway for a long time. Because of the heavy loading pavement distresses can occur like stripping, ravelling, cracking and moisture damage due to water penetrate through porous asphalt. When there is presence of water, the bonding between aggregate and bitumen will become weakens so the moisture damage can happened. While water ponding is when water is unable to drain away caused by lack of water runoff toward the drain. Besides that, heavy traffic loads

tends to affect the performance of asphalt mixture in term of its resilient modulus. Therefore, this research is to assess the accomplishment of porous asphalt incorporating steel fiber and overcome the issue that is related to porous asphalt.

The result of the research will conclude the advantage of steel fiber existence in reducing the issues of pavements. Among the advantage of fiber is to assure pavement strength, and fiber may be combined to the mixtures to boost the performance, control shrinkage, have longer pavement life, raise structural stability, and increasing rut resistance.

By using steel fiber as a modifier, the mixtures will be tested so as to determine the optimum fiber content of fiber modified porous aphalt.in order to recover the performance of porous asphalt. Therefore, in this study, type of fibers that we used is steel fiber which would help to achieve the better performance of pavements. Steel fiber also would have a lot of influence towards improving the properties of PA.

1.2 PROBLEM STATEMENT

Pavements in road always exposed to the heat and precipitation throughout the day. Therefore, a chance to the damage of the pavements will be high especially when the structure is reacting toward the presence of water. Fluids are one of the weaknesses for common asphalt mixtures. Therefore, when water penetrates through asphalt, the pavements will face a deficiency for instance moisture damage, rutting, stripping and water ponding. After heavy rain, water ponding tend to happened because of lack of water runoff toward the drain so the water unable to drain away. Besides that, massive traffic loads lean to influence the accomplishment of asphalt mixture in term of its flexible modulus. Therefore, a way to overwhelm this distress behaviour is by adjusting the asphalt by the properties. Hence, fiber have a tendency to deliver enhancement of properties for construction material and this analysis envisioned to endorse fiber-material as additives in order to recover the properties of asphalt mixtures.

1.3 OBJECTIVE

1. To evaluate mechanical performance of steel fiber modified porous asphalt.

2. To determine the optimum fiber content of steel fiber modified porous aphalt.

3. To evaluate the performance of porous asphalt incorporating steel fiber in terms of abrasion, Marshall Stability and Flow, Resilient Modulus and Dynamic creep.

1.4 SCOPE OF RESEARCH

For this study, the asphalt binder will be 60/70 PEN for unmodified sample while PEN 60/70 with steel fiber was used for the modified sample. Porous asphalt mixtures were ready by adding steel fibers as an additive in the mixtures. A total of 48 samples were ready for porous asphalt mixtures at different percentages of fiber content ranging from 0% to 0.6% and the 0% as a reference between modified and unmodified asphalt samples. The requirement that will be used for this research is in accordance to Malaysian Public Work Department for road works (JKRSPJ2008).

To plan the mixtures, Marshall Mix Design technique will be used and lead to resolve the volumetric properties and carry on with the best possible asphalt binder content. Among the test of asphalt binders is including penetration test at 25^{o}C, softening point test and ductility test that were carried out. From penetration test we can know the rigidity and constancy of asphalt binder before it may be applied on street. To decide the temperature at which given asphalt binder reaches a certain points of softness and get the result for flow and constancy of asphalt binder can be known from softening point test. In addition, ductility test is to illustrate the ductility of asphalt binders.

Next, from Marshall Mix design, we can prepare the samples in order for determination of firmness and flow in the Marshall equipment and to decide density, fractions of air voids, percentage of density and percentage of aggregate voids fulled with binder. There are four tests for performance which is Cantabro test, Marshall Stability and flow test, resilient modulus and Dynamic creep that involve in identifying the optimum fiber content for the best performance of asphalt.

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